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Free-roaming Kissing Bugs, Vectors of Chagas Disease, Feed Often on Humans in the Southwest

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Abstract

BACKGROUND—Kissing bugs, vectors of *Trypanosoma cruzi*, the parasite that causes Chagas disease, are common in the desert Southwest. After a dispersal flight in summer, adult kissing bugs occasionally gain access to houses where they remain feeding on humans and pets. How often wild, free-roaming kissing bugs feed on humans outside their homes has not been studied. This is important because contact of kissing bugs with humans is one means of gauging the risk for acquisition of Chagas disease.

METHODS—We captured kissing bugs in a zoological park near Tucson, Arizona, where many potential vertebrate hosts are on display, as well as being visited by more than 300,000 humans annually. Cloacal contents of the bugs were investigated for sources of blood meals and infection with *T. cruzi*.

RESULTS—Eight of 134 captured bugs were randomly selected and investigated. All 8 (100%) had human blood in their cloacae, and 7 of 8 (88%) had fed on various vertebrates on display or feral in the park. Three bugs (38%) were infected with *T. cruzi*. Three specimens of the largest species of kissing bug in the United States (*Triatoma recurva*) were captured in a cave and walking on a road; 2 of 3 (67%) had fed on humans. No *T. recurva* harbored *T. cruzi*.

CONCLUSIONS—This study establishes that free-roaming kissing bugs, given the opportunity, frequently feed on humans outside the confines of their homes in the desert Southwest and that some harbored *T. cruzi*. This could represent a hitherto unrecognized potential for transmission of Chagas disease in the United States.

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Keywords

Chagas disease; Kissing buds; Triatominae; *Trypanosoma cruzi*

Eleven species of hematophagous kissing bugs are found in the United States, and all potentially harbor *Trypanosoma cruzi*, the parasite that causes Chagas disease. Kissing bug home ranges extend northward into the bottom two thirds of the United States; however, the nearest endemic area of Chagas disease in humans is in Mexico.[1] Yet, with climate change and possible changes in the behavior of kissing bugs, there is a potential for an increase in the number of vector-transmitted human infections with *T. cruzi* in the United States.[2]

Adult kissing bugs in the Southwest undergo a dispersal flight before the monsoon rains during the hottest days of summer and are attracted to lights near and on houses,[3] which they may enter beneath door thresholds and through window casings and feed on pet and human inhabitants (Figure 1). This occasionally leads to human anaphylaxis[4] or, rarely, infection, in the United States. Kissing bugs are nuisances in homes in San Diego, California, and Phoenix and Tucson, Arizona.[4]

Chagas disease in Latin America is closely linked to house construction with thatch roofing and wattle and daub walls that provide numerous crevices for bugs to hide. Kissing bugs colonize these homes and peri-domestic structures and may achieve densities of more than 1000 bugs per home. In this setting, contact with humans occurs frequently and often leads to infection. In contrast, home construction in the warmer parts of the United States where kissing bugs reside is different, with an emphasis on energy conservation and sealing of homes for air conditioning. Furthermore, use of solid wall and roof construction, features not conducive to colonization by kissing bugs, is standard in construction. Nevertheless, there are 7 well-documented autochthonous cases of Chagas disease in the United States.[5] Five of the seven cases involved infants or young children who presumably were infected in the home or the immediate environs. There may be more autochthonous cases.[6] A well-documented example of autochthonous Chagas disease is a 74-year-old woman in New Orleans Parish, Louisiana, who was acutely infected with Chagas (*T. cruzi* was cultured from her blood). More than 20 adult kissing bugs were found in her home; 56% harbored *T. cruzi*. Neither nymphs nor eggs were found in the house, indicating that the home was not colonized. However, the house was 29 years old and provided many gaps for entry of bugs.[7]

Contact between kissing bugs and humans is an important indicator of the potential risk for Chagas disease and can be determined by investigating the frequency of human blood feeding. As mentioned, kissing bugs feed on humans when trapped in houses after a dispersal flight, but little is known about the feeding habits of wild, free-roaming bugs. Is it possible that kissing bugs, like mosquitoes, feed on people engaged in outside activities? To answer this question, we determined the blood meal sources of wild kissing bugs captured in a zoological park in close proximity to a variety of vertebrates. Our findings indicate that wild-caught bugs feed often on humans in addition to large and small vertebrates.

MATERIALS AND METHODS

Ultraviolet “black lights” were set up in the desert in areas providing a clear flight path for the insects from all directions to the light source. A total of 134 kissing bugs (121 *Triatoma rubida* and 13 *Triatoma protracta*) were collected using ultraviolet lights at the Arizona-Sonora Desert Museum (ASDM), Tucson, Arizona, in May and June 2009. In addition, 2 wild adult *Triatoma recurva* were collected on a roadway in Bisbee, Arizona, and 1 was collected in Colossal Cave, Arizona. These are the 3 most common kissing bugs in southern Arizona. Bugs were placed in individual vials with 95% ethanol + 5% glycerol. Of the 134 insects captured at the ASDM, 8 were randomly chosen to include both sexes, species, and collection sites. Blood sources[8] and *T. cruzi* parasite infection[7] using primers from Moser et al[9] were determined for each insect as previously reported.[10] By using universal vertebrate primers for the mitochondrial *12S* ribosomal gene,[11,12] a broad net was cast to potentially identify as many blood meals as possible. Previous work established that assays based on the *12S* gene detected more blood meal sources than an assay based on the mitochondrial cytochrome B gene.[10] The polymerise chain reaction products were cloned and sequenced to isolate multiple blood meals within a single insect. Blood meal sources were inferred by using BLAST (http://blast.ncbi.nlm.nih.gov/Blast.cgi). Seventy-one clones from 11 bugs containing vertebrate blood were isolated and characterized. All had more than 98%, 99%, or 100% matches with the BLAST searches.

RESULTS

Eight of 8 (100%) of the kissing bugs randomly selected from among 134 bugs captured at the ASDM showed evidence of having fed on humans (Figure 2), as did 2 of 3 *T. recurva*, 1 from Bisbee, Arizona, and 1 from Colossal Cave, Arizona. The vertebrate taxa for the blood meals for kissing bugs captured in the museum in addition to animals on display or feral in the museum are shown in Table 1. On average, there were 2.9 ± 1.1 different blood sources per bug. The museum exhibits 106 living mammals of 31 taxa, 241 birds of 72 taxa, and 361 reptiles of 86 taxa that are potential blood meal sources for kissing bugs. In addition to these animals in captivity, an unknown number of native fauna live free on the grounds. Pigs (*Sus scrofit*) appear to be a favorite food source for kissing bugs, with 6 of 8 bugs having fed on pigs. However, there are no known domestic or feral pigs within 1 mile of the museum; thus, we infer that there are unknown feral pigs in areas immediately surrounding the park or bugs are flying into the park after having fed on pigs. There are numerous javelinas (collared peccaries) on display and feral in the park, but the DNA match was closest to pig, not javelina. Other captive hosts also served as blood meal sources, including wolf or coyote (these 2 species of animal are displayed in 2 separate enclosures) in 2 bugs, desert bighorn sheep (*Ovis canadensis*) in 2 bugs, and rodents in 2 bugs. Opossum blood was detected in 1 bug. This animal is uncommon in Arizona and would be free-ranging on the museum grounds because it is not displayed.

Humans constitute the greatest biomass of potential food sources for resident bugs. There are approximately 370,000 visitors per year, and the museum employs 100 individuals and more than 500 volunteers. There is a guesthouse where people stay overnight periodically, and maintenance staff is present at night. In the months of June to August, the museum

sponsors a popular weekly nighttime venue where visitors tour the grounds and enjoy the restaurants, thus providing opportunities for kissing bugs to feed day and night on humans.

Three wild *T. recurva* kissing bugs had 2 ± 1 blood sources per bug. One *T. recurva* from Bisbee, Arizona, and another caught inside Colossal Cave, Arizona, had evidence of human blood. Two of the *T. recurva* also had been feeding on opossum and *Canis* spp. blood.

Three bugs captured at the ASDM were infected with *T. cruzi*, and all 3 of these bugs had evidence of having fed on humans. One kissing bug was *T. protracta*, and the other 2 were *T. rubida*. No *T. recurva* harbored *T. cruzi*.

DISCUSSION

Kissing bug bite reports are highest for the months of May and June in Tucson during periods of dispersal when bugs enter households. A study of a southern California community demonstrated that 6.7% of the population possessed antibodies to *T. protracta* salivary antigens and, thus, were fed on by these bugs. A recent survey in Riverside County in California showed that self-reported allergies to kissing bug bites occurred in 13% of the rural population.[14] Thus, kissing bug bites are not uncommon Reactions to kissing bug bites are characteristic and may lead to local and occasionally systemic allergic reactions.[4,15] In Phoenix, Arizona, 1 patient died after a bite led to anaphylaxis.[16] Kissing bug bites are usually painless, which means that many humans are entirely unaware of being bitten.[17] The majority of bite reports, including the described examples, occur after the entry of bugs into houses after their dispersal flight. They commonly feed on the homeowners and pets for months or until discovered.

Kissing bugs are occasionally found in peridomestic structures around the household environment. For example, in Texas they reside in doghouses feeding on and infecting resident dogs with *T. cruzi*.[18] We are aware of 1 southern Arizona city where domestication may actually have occurred with the largest species in the United States, *T. recurva*. In Bisbee, Arizona, *T. recurva* is resident throughout the year in older houses and feeds regularly on humans with all life stages present in the homes (Figure 3).[19] Three *T. recurva* are reported in the current article (Table 1). One of 2 bugs captured in Bisbee, Arizona, and 1 bug captured within Colossal Cave, Arizona, displayed evidence of human blood. These were all free-roaming bugs (Table 1).

Three bugs captured at the ASDM were infected with *T. cruzi*, and all 3 of these bugs had evidence of having fed on humans. One kissing bug was *T. protracta*, and the other 2 were *T. rubida*. Overall, in the sample of captured bugs at the ASDM (n = 134), the carriage of *T. cruzi* for *T. protracta* was 35% (n = 13) and of *T. rubida* was 25% (n = 121) (not statistically different rates).[20] No *T. recurva* harbored *T. cruzi*.

We previously reported that 38% of wild kissing bugs (5/13) from Arizona and California demonstrated evidence of feeding on humans.[8] We now report the results from a larger sample of bugs in an attempt to identify all of the vertebrate hosts that served as blood meal sources and show unambiguously that wild-caught kissing bugs feed commonly on humans. The bugs had ample opportunity to feed on many different captive vertebrates and feral

vertebrates in the zoological park and surrounding areas. They obviously were not averse to feeding on human hosts as well—perhaps preferring human blood. So far, contact and feeding of kissing bugs do not necessarily lead to human infection with *T. cruzi* in the United States, which has a low incidence of autochthonous cases. It is interesting to note that a recent article from the Yucatan reports a high incidence of *Triatoma dimidiata*, an important vector of Chagas disease in Central America, feeding on humans but a very low incidence of Chagas disease.[21]

CONCLUSIONS

We show that wild, free-roaming kissing bugs feed commonly on humans in the desert Southwest. Although the bugs had ample opportunity to feed on many different captive vertebrates in a zoological park and surrounding area, they were not averse to feeding on human hosts.

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CLINICAL SIGNIFICANCE

- Free-roaming kissing bugs, vectors of Chagas disease, take blood meals from many different mammals in the wild.
- Free-roaming kissing bugs also feed on humans (when outside their homes), if given the opportunity.
- Because contact of kissing bugs with humans is one measure of the risk for Chagas disease, this feeding on humans (when outside their homes) may be an unrecognized risk factor for vector-transmitted Chagas disease in the United States.

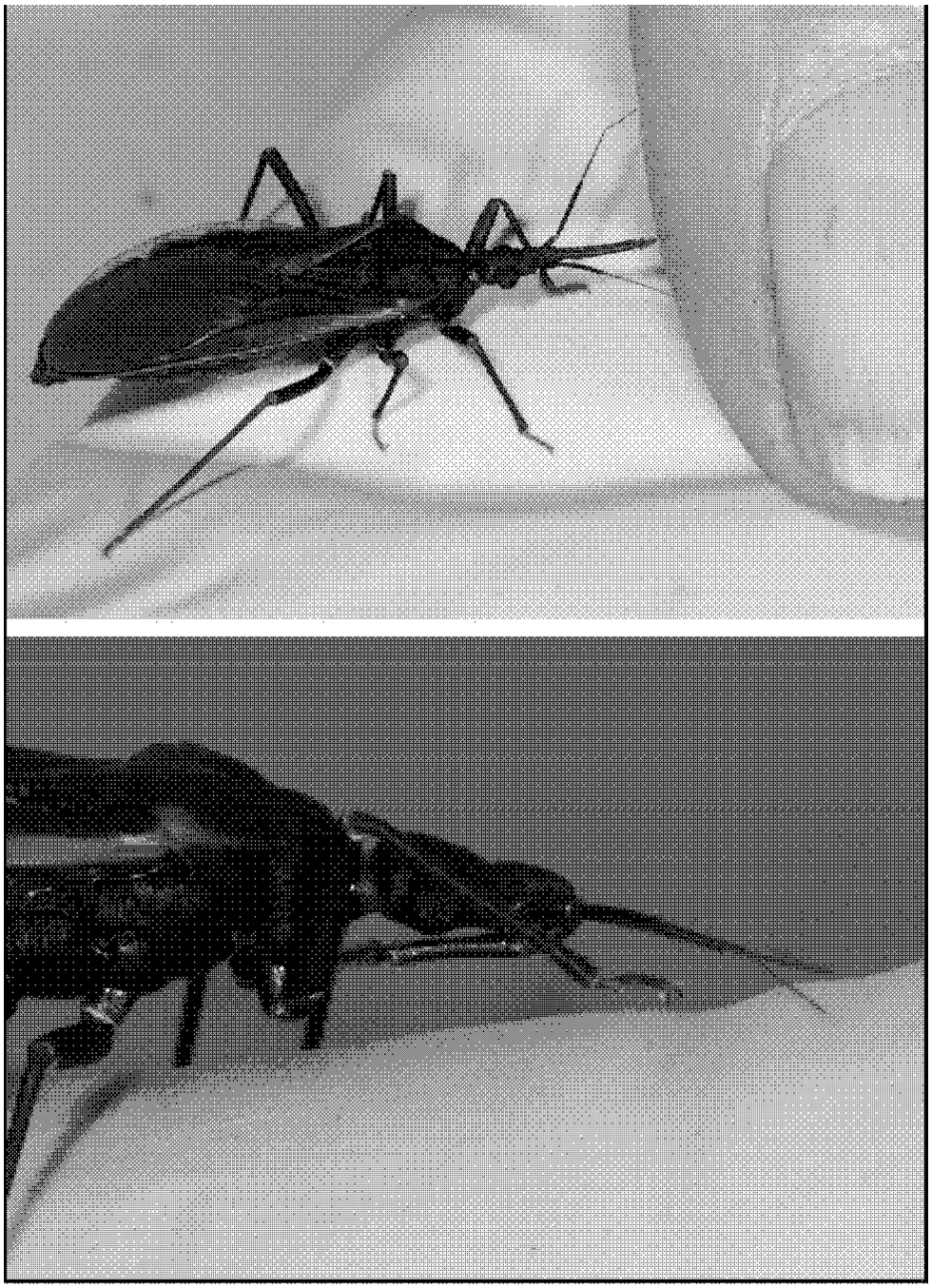

Figure 1. ***Top*****: Adult female** ***Triatoma ruhida*** **preparing to feed**

Note the extended proboscis. When starved of a blood meal for approximately 2 weeks, these voracious bugs immediately begin to feed, even disregarding handling and removal from their habitat. Blood meals may take minutes to a half an hour to complete and are often interrupted by movement of the host. *Bottom*: Proboscis folded ventrally when not feeding.

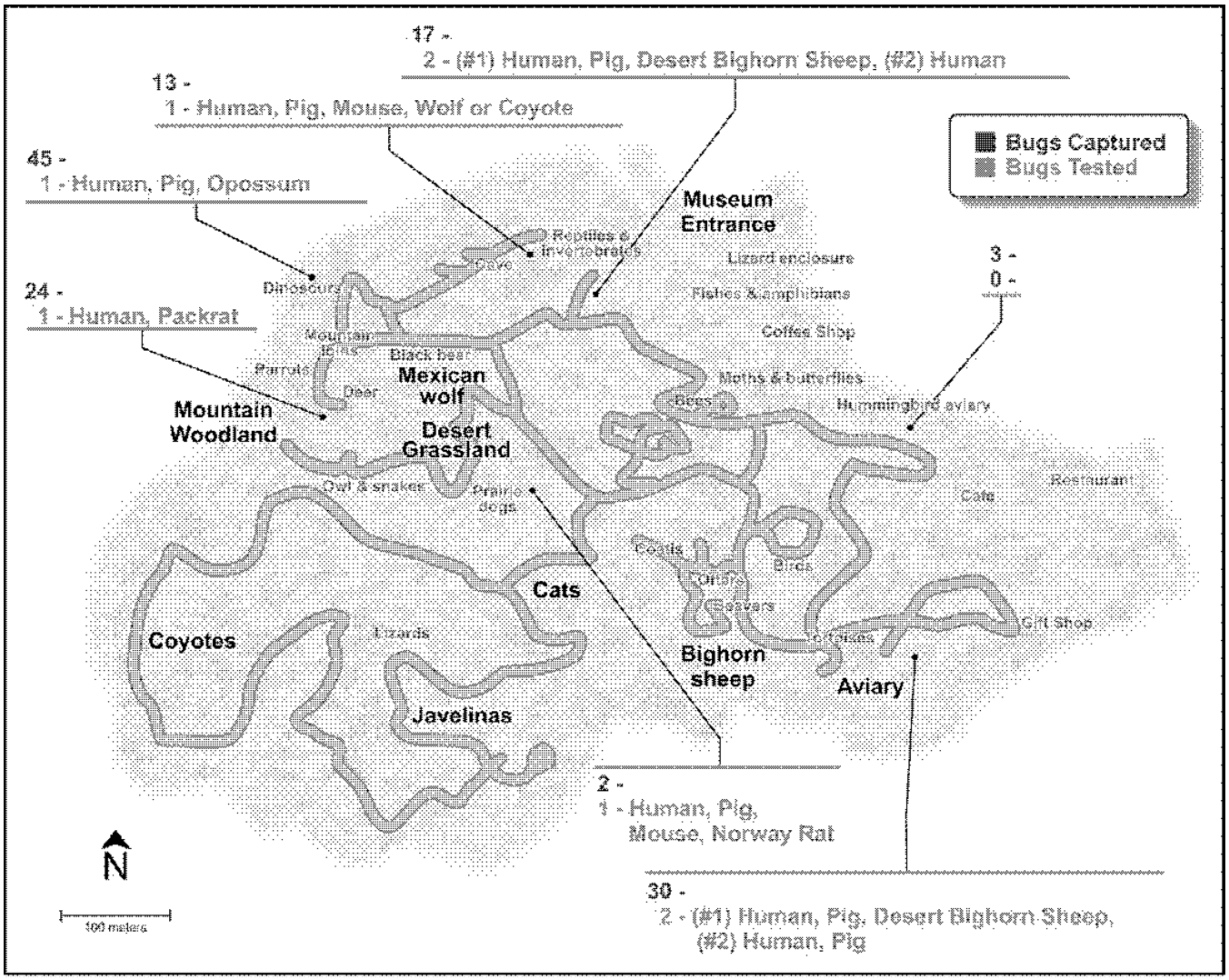

Figure 2. Map of kissing bug collection sites at the ASDM

Seven sites are shown with the number or bugs captured at each site (in purple) and the blood sources found in the bug (in orange). Map shows walkway through the museum grounds with the various major displays.

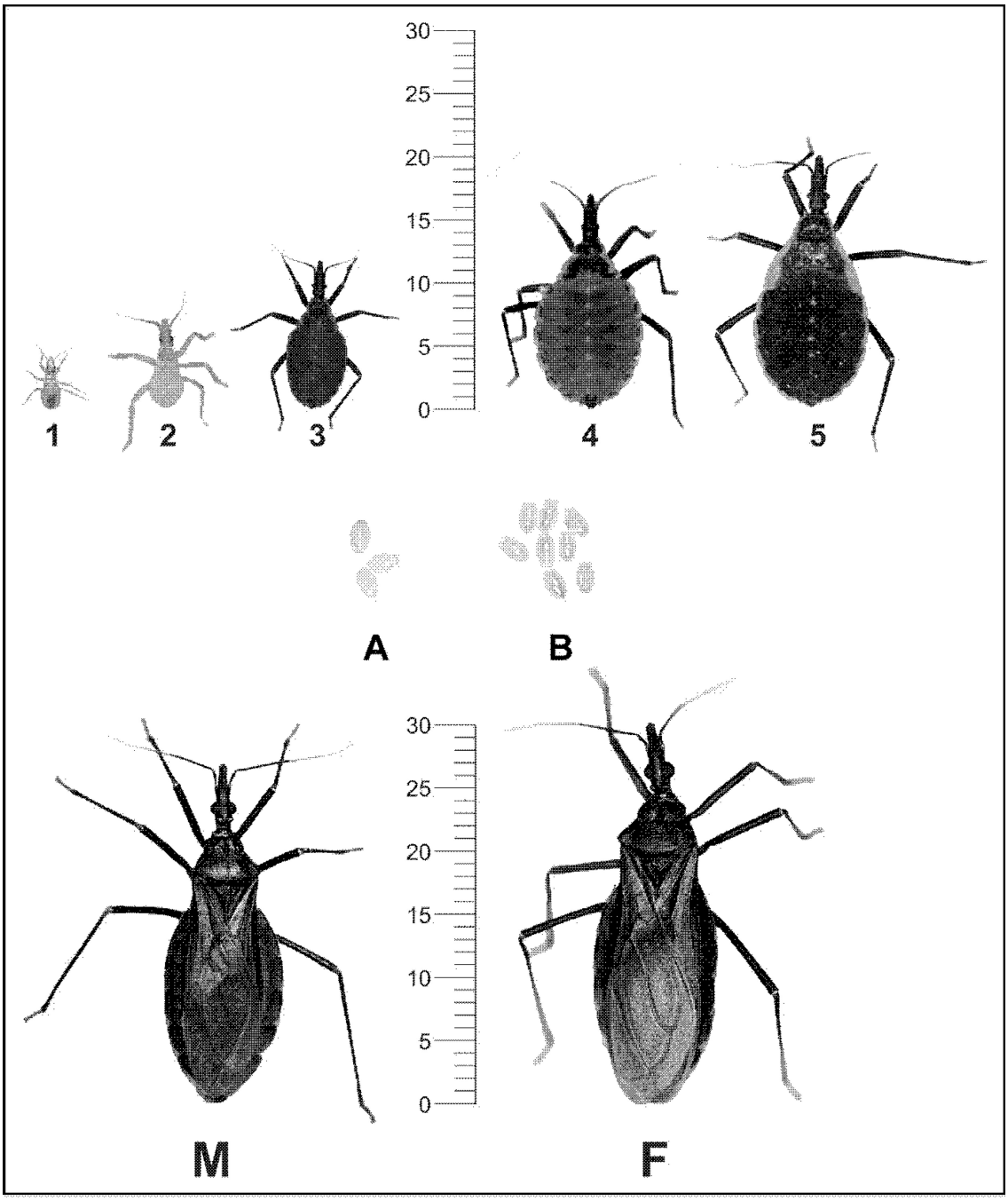

Figure 3. Life cycle of *Triatoma recurva* (millimeter scale)

Top: nymphal stages 1 to 5. Each requires 1 or more blood meals before molting to the next stage. (**A**). Fertile egg. (**B**). Egg casing. *Bottom*: adult male *T. recurva* on the *left* and female on the *right*.

Table 1

Animal Taxa Found in Blood Meals form Kissing Bugs Captured at the Arizona-Sonora Desert Museum

Where Trapped in ASDM	Triatomine Species and Sex	*Trypanosoma cruzi* Present (PCR)?	Animal Taxa Found in Blood Meal	Animal on Display (or Feral)
Aviary	*Triatoma rubida*/female	Negative	*Canis lupus*	Wolf, coyote, domestic dog
			Ovis sp. (sheep) or *Capra sp.* (goat)	Desert bighorn sheep
			Human	
			Sus scrofa	
Aviary	*T. rubida*/male	Positive	*Sus scrofa*	
			Human	
Dinosar display	*Triatoma protracta*/female	Positive	*Didelphis*	Feral opossum
			Human	
			Sus scrofu	
Cave area	*T. rubida*/female	Negative	*Canis lupus*	Wolf, coyote, domestic dog
			Human	
			Mus musculus	Feral mice in park
			Sus scrofa	
Grasslands	*T. rubida*/male	Negative	Human	
			Mus musculus	Feral mice in park
			Rattus norvegicus	Feral rats in park
			Sus scrofa	
Mountain woodland	*T. rubida/female*	Positive	Human	
			Neotoma spp.	Feral packrats common in park
Entrance	*T. rubida*/female	Negative	*Ovis* sp. (sheep) or *Capra sp.* (goat)	Desert bighorn sheep
			Human	
			Sus scrofa	
Entrance	*T. rubida*/female	Negative	Human	
Colossal Cave	*T. recurva/male*	Negative	Human	
Bisbee, Ariz	*T. recurva/male*	Negative	Human, *Didelphis*, *Canis*	Feral opossum, domestic dog, coyote
Bisbee, Ariz	*T. recurva/female*	Negative	*Didelphis*, *Canis*	Feral opossum, domestic dog, coyote

Large enclosure containing the grey wolf, coyote, and desert bighorn sheep (*Canis lupus*, *Canis latrans*, and *Ovis canadensis*, respectively) are present in the museum. The packrat (*Neotoma* spp.), rat (*Rattus norvegicus*), opossum (*Didelphis* spp.), and mouse are feral animals on the grounds. Animal taxa determined by BLAST match.

PCR = polymerase chain reaction.